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Wireless RF Module Speed Synchronization of Multiple Motor's in Industries based on PLC and SCADA

Supriya Kumari, Qamar Alam, Imran Ali, Mirza Mohd Shadab
Department of Electrical Engineering, Integral University, Lucknow, India
E-mail: mmshadab@iul.ac.in

Abstract

Multiple motor in industries like textile mills, paper mills and steel plants etc. use conveyer belts, for the synchronization of motor to maintain constant loads. This is achieve by interfacing independent PLC to each motor with a speed sensing arrangement with PLC, variable frequency drive (VFD) along with SCADA system. In this paper, prototype hardware is developed and their performance is seen. The objective of this paper is to synchronize the speed of multiple motor in industries using programmable logic controller (PLC) and Supervisory Control and Data Acquisition system (SCADA). The whole information of each motor will be displayed on SCADA screen like, RPM, motor ON/OFF and speeds mismatch display and alarm system.

Keywords: *Synchronization, PLC, SCADA, speed, frequency*

INTRODUCTION

The aim of this paper is synchronization of multiple motors using wireless technology. It uses radio frequency to synchronize motor speeds. This is applicable to many industries like textile mills, steel plants and paper plants wherein all the motors used on conveyor are desired to be synchronized. In textile mills where multiple motors work simultaneously on a conveyor belt to draw clothes, it is essential that all the motors there should run at same speed, so that

balanced tension is achieved to avoid clothes getting damaged. Motors are wirelessly synchronized to make the differential speed error among multiple motors to zero. One motor acts as transmitter and all the rest as receivers [1]. Thus, if a particular speed is set in the transmitter then all other motors speed would be matched to the same speed of the main motor. The mode of communication is radio frequency. Induction motors used to operate on the basis of PWM control. Each motor has a closed loop feedback mechanism providing RPM reference by a shaft mounted IR sensor arrangement whose output is fed to the controller in the circuit. A display unit SCADA Displays the full speed and one can enter the desired percentage with help of a keypad to obtain the required speed for all the motors. The pulse width output from the PLC would be automatically adjusted to maintain the DC power to the motor such that the entered speed percentage matches the running RPM. The above operation is carried out by using one VFD for driving the S.C.I.M motor duly interfaced from PLC [2].

In various stages of operations motors have to rotate at different speeds, so if we change the speed in transmitting motor then rest of the motors are adjusted accordingly, but for un adjustable fault, certain logic and intelligence can be created to the whole system so that if any of the motor senses any fault, the whole system will shutdown the whole operation and harmful consequences can be eliminated. It also detects all type of fault like, over current, over voltage, over loading etc.

IMPORTANCE OF SPEED SYNCHRONIZATION

The speed synchronization is very essential requirement of the industry in which large No. of motors are running to produce identical products simultaneously otherwise quality as well product dimension will be different so by using RF module speed synchronization of multiple motor's based on PLC and SCADA can fulfill the above requirement and minimize the above problem up to the required level. This technique is simple and less complex and easy to control. It save energy and power reduces human effort, frequent maintenance cost of product, operating time and increases reliability, productivity of the system, as well as life of the system [3].

DESCRIPTION OF COMPONENTS

Programmable Logic Controller (PLC)

A Programmable Logic Controller, PLC or Programmable Controller is a digital computer used for automation of industrial processes, such as control of machinery on factory assembly lines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise and resistance to vibration and impact.

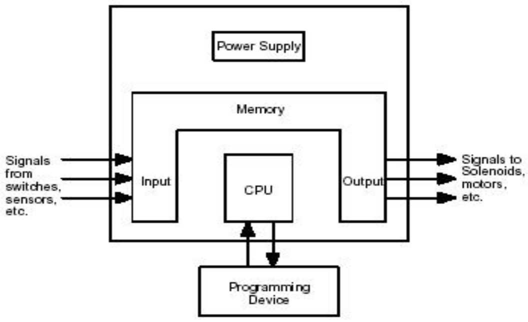

Fig. 1: *PLC Block Diagram.*

Programs to control machine operation are typically stored in battery-backed or non-volatile memory. A PLC is an example of a real time system since output results must be produced in response to input conditions within a bounded time; otherwise unintended operation will result. PLC and Programmable Logic Controller are registered trademarks of the Allen-Bradley Company [4].

Wiring in a PLC

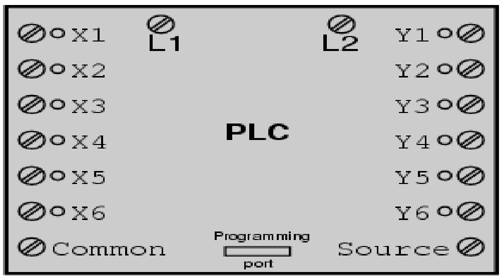

Fig. 2: *Showing pin Diagram of a PLC.*

Generation of Input Signal

Inside the PLC housing, connected between each input terminal and the Common terminal, is an opto-isolator device (Light-Emitting Diode) that provides an electrically isolated "high" Logic signal to the computer's circuitry (a photo-transistor interprets the LED's light) when there is 120 VAC power applied between the respective input terminal and the Common terminal [5]. An indicating LED on the front panel of the PLC gives visual indication of an "energized" input.

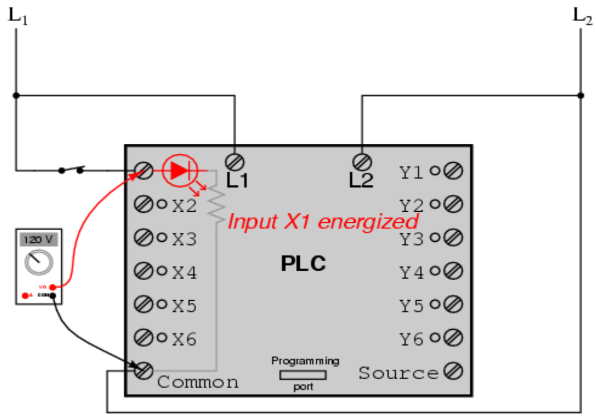

Fig. 3: *Diagram Showing Energized Input Terminal X1.*

Generation of Output Signal

Output signals are generated by the PLC's computer circuitry activating a switching device (transistor, TRIAC or even an electromechanical relay), connecting the "Source" terminal to any of the "Y-" labelled output terminals. The "Source" terminal, correspondingly, is usually connected to the L1 side of the 120 VAC power source. As with each input, an indicating LED on the front panel of the PLC gives visual indication of an "energized" output.

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In this way, the PLC is able to interface with real-world devices such as switches and solenoids. The actual logic of the control system is established inside the PLC by means of a computer program.

This program dictates which output gets energized under which input conditions. Although, the program itself appears to be a ladder logic diagram, with switch and relay symbols, there are no actual switch contacts or relay coils operating inside the PLC to create the logical relationships between input and output.

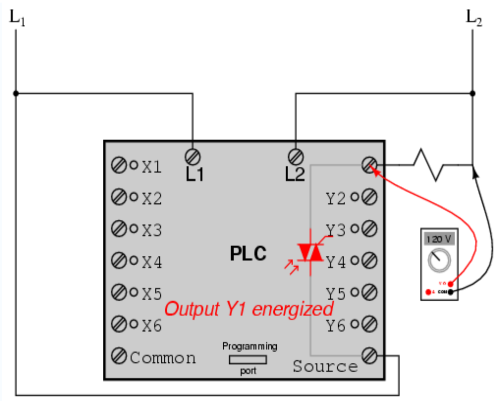


Fig. 4: *Diagram showing Energized Output Y1.*

Ladder Logic

Ladder logic is a method of drawing electrical logic schematics. It is now a graphical language very popular for programming Programmable Logic Controllers (PLCs). It was originally invented to describe logic made from relays.

The name is based on the observation that programs in this language resemble ladders, with two vertical "rails" and a series of horizontal "rungs" between them. A program in ladder logic, also called a ladder diagram, is similar to a schematic for a set of relay circuits.

Description of PLC Program

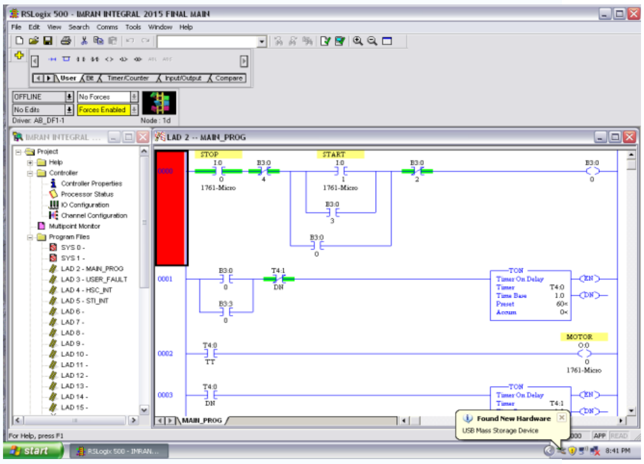


Fig. 5: *Ladder Diagram of Speed Synchronization.*

From the above ladder logic diagram, we use NO type START button and NC type STOP button for PLC and use same both button for SCADA in series and parallel manner in diagram. If we press input START button of PLC then the output of PLC O1 is high whose address command is B3:0/0 and it hold current and become high. All these same process can also be done with SCADA.

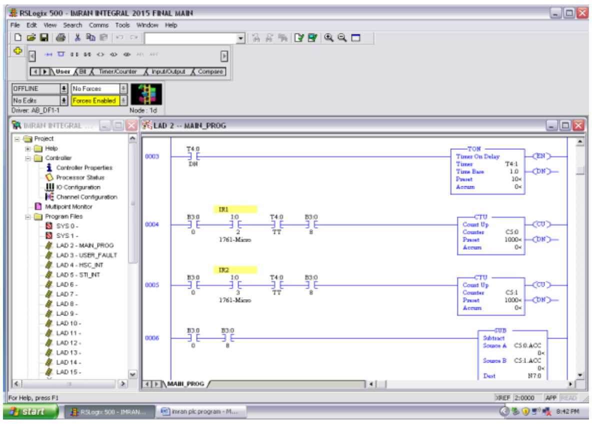


Fig. 6:

When binary B3:0/0 is high then NO become NC and gives the signal to TIMER, as the timer start, both motor will start and run for 60 sec. After 60 sec both motor will stop and at that time DEN bit is high for 10 sec. It is the resting time of both motor. We can say it also a Delay Time. After completing 10 sec delay both motor will start automatic.

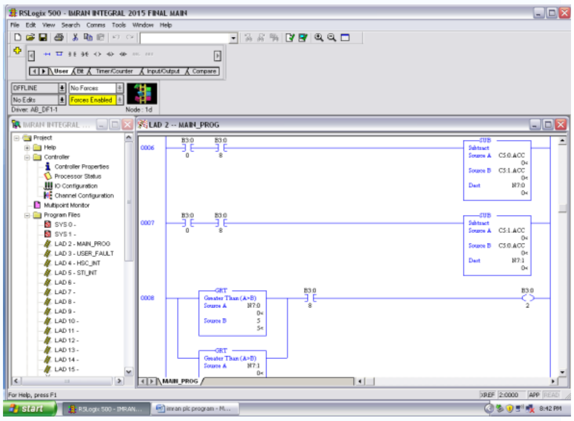


Fig. 7:

Both motors are run in same RPM as we set and speed is synchronized. The RPM (revolution per minute) of both motor are count by IR sensor which is coupled with motor shaft. When both IR sensors count one pulse then at that time input signal of I: 0/2 is high for one motor and I: 0/3 is high for second motor.CTU (counter) C5:0 and C5:1 count the every pulse of both motor through IR1 and IR2.

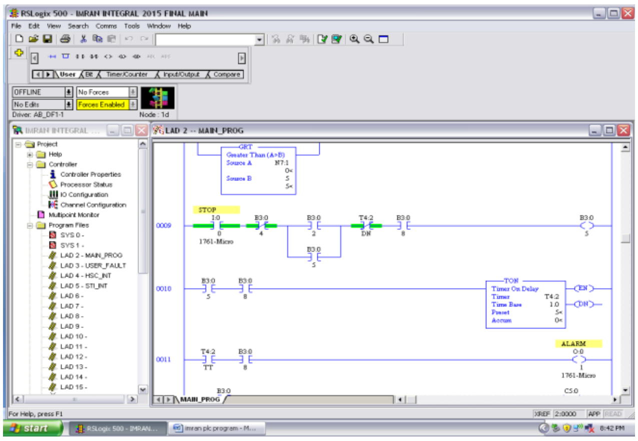


Fig. 8:

Source A whose address is N7:0 and source B

Whose address is N7:1, In GRT (greater than) box (A>B) we compare both motors RPM. If difference is greater than 5RPM (as we set) then both motors will stop and create an alarm. Then operator checks the fault and reset the machine, the above process is close loop. For running the motors in open loop system we press the START button two times within two second (as according to set time of operator), then B3:0/9 will high and motor will run on open loop system.

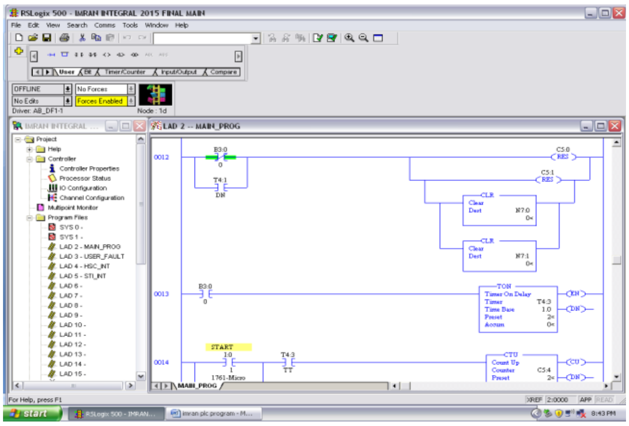


Fig. 9:

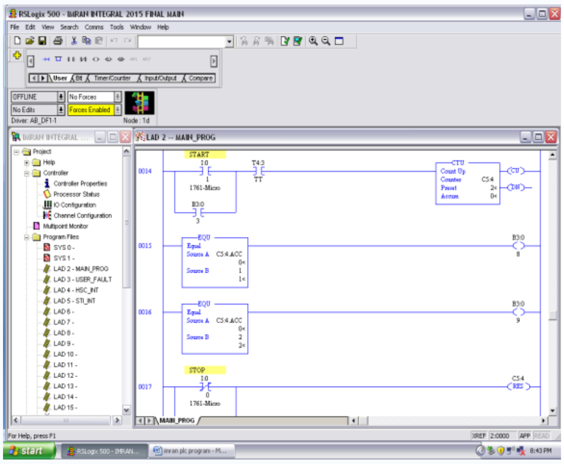


Fig. 10:

We use open loop system in case of both sensors will fail. This method is called is bypass method. In this method motors will not stop working, it will remain continue to run. In an open loop system, there is no mean of speed synchronization. This method is only for emergency case to avoid stop the process. When close loop system is working then binary B3:0/8 will high and this is given to the entire above close loop address.

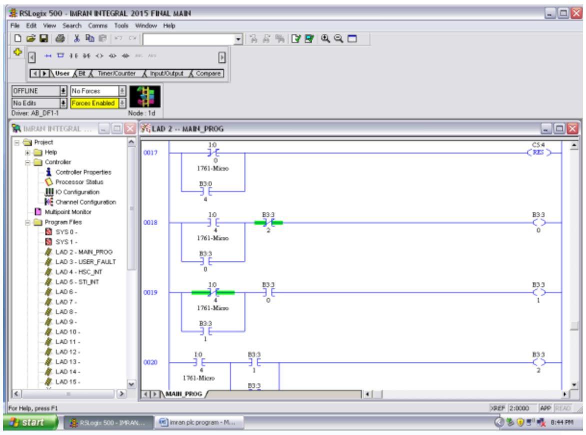


Fig. 11:

In this RF module is also used to run the motors in bypass mode. The operator operate it by the remote and they can control the motors from anywhere within 30 meter range. This process save the time of operator.

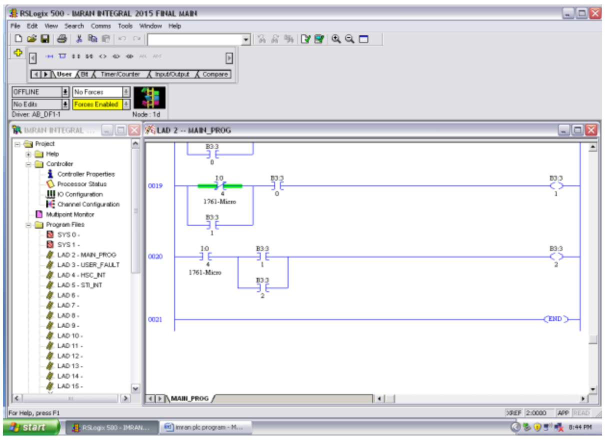


Fig. 12:

Supervisory Control and Data Acquisition

SCADA (supervisory control and data acquisition) is a system operating with coded signal over communication channels of remote equipment. The control system may be combining with a data acquisition system by adding the use of coded signal over communication channels to acquire information about the status of the remote equipment for display or for recording function. It is a type of Industrial Control System.

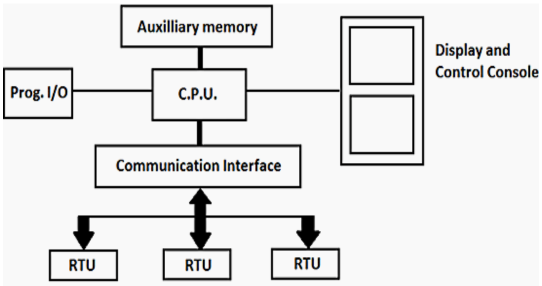


Fig. 13: *SCADA System with Single Computer*.

Description of SCADA Programme

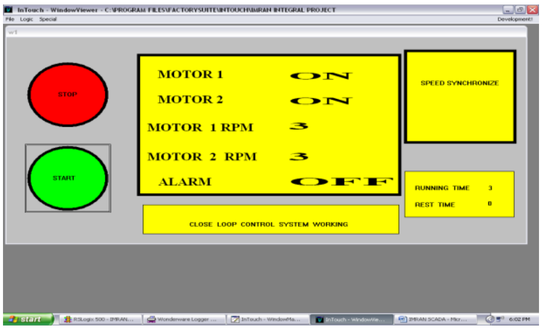


Fig. 14: *Speed Synchronization on SCADA Pannel using Close Loop System.*

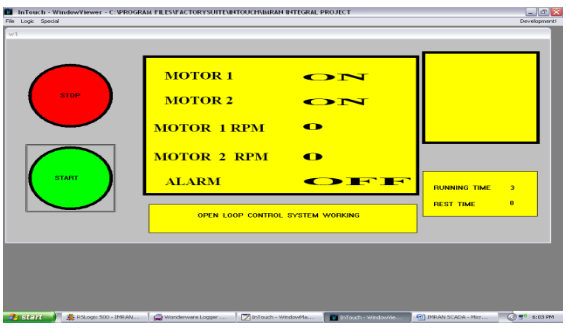
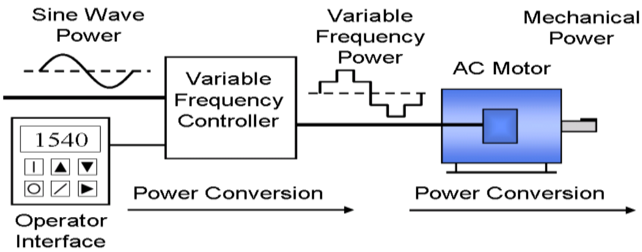


Fig. 15: *Speed Synchronization on SCADA Panel using Bypass Method.*

Variable Frequency Drive or VFD

A variable-frequency drive (VFD) (also termed adjustable-frequency drive) is a type of adjustable-speed drive used in electro-mechanical drive systems to control AC motor speed and torque by varying motor input frequency and voltage.



VFDs are used in applications ranging from small appliances to the largest of mine mill drives and compressors. However, around 25% of the world's electrical energy is consumed by electric motors in industrial applications over the last four decades, power electronics technology has reduced VFD cost and size and has improved performance through advances in semiconductor switching devices, drive topologies, simulation and control techniques, and control hardware and software [1].

RF Module

An RF module (radio frequency module) is a (usually) small electronic device used to transmit and/or receive radio signals between two devices. In an embedded system it is often desirable to communicate with another device wirelessly.

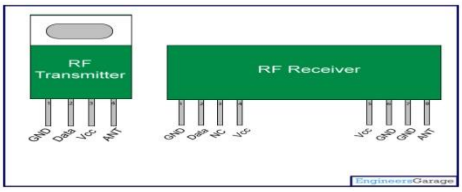


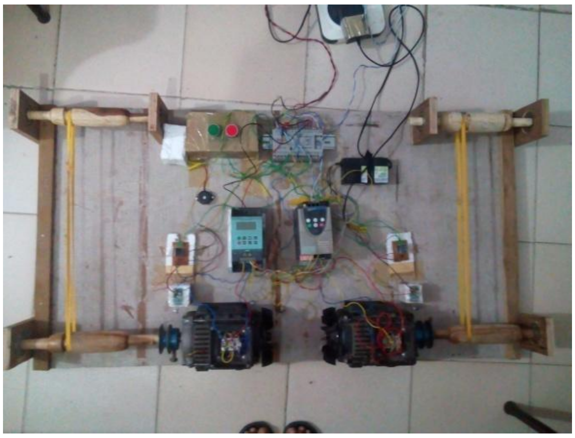
Table 1: *Pin Description: RF Transmitter.*

Pin No.	Function	Name
1	Ground (0 V)	Ground
2	Serial Data Input Pin	Data
3	Supply Voltage; 5 V	Vcc
4	Antenna Output Pin	ANT

Table 2: *RF Receiver.*

Pin No.	Function	Name
1	Ground (0V)	Ground
2	Serial Data Output Pin	Data
3	Linear Output Pin; Not Connected	NC
4	Supply Voltage; 5 V	Vcc
5	Supply Voltage; 5 V	Vcc
6	Ground (0 V)	Ground
7	Ground (0 V)	Ground
8	Antenna Input Pin	ANT

Working of Hardware



When we press start push that is wired to PLC input I1 Port, PLC will energize and O0 output port of the PLC will high and O0 output will send wired command to VFD No 1 and VFD No 2, at same time and both VFD will send power command, three phase voltage to both motors to run at same at low speed that is set by our potentiometer to both VFD.SCIM Motor will be run for time period of one minute and automatic turn off after one minute and take a rest time of ten second again turn on automatic after completion of ten second time. For both motor running in same speed, we are using closed loop feedback for speed control for this purpose we are using the IR Sensor to check the RPM of the both motor for every rotation of the motor in second. IR sensor send the counting pulse to plc input to check the RPM in his internal counter and if found speed mismatch then PLC o/p will cut off the conveyor motor automatic and create the alarm to rectify the speed mismatch problem.

COMPONENTS USED

One SMPS (Switched Mode Power Supply) for PLC power of 24 V, 2 A
One PLC Micrologix-1000-controller
One NC Push button (start push button)
One NC Push button (stop push button)
Two VFD (variable frequency drive)
One Conveyer (wood)
Two Squirrel cage induction motor of same ratings
Two IR sensor board, 5 volt dc operated
Two Relay driver board
Two LED
Two Resistance of 10 kΩ
One set of SCADA Terminal with one Laptop, RS232 to USB

CONCLUSION

In this paper prototype hardware is developed and their performance is seen. The synchronization in the speed of two motor is successfully implemented and it can be used for multiple motors. In this we synchronize the speed of motors using close loop and open loop method. Corrective action is taken within a few second if any error in the speed occurs then it shows on the SCADA display. In this smart controlling and speed synchronization with the help of SCADA system will enhance the productivity, reliability and safety for whole systems.

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